Curriculum Vitae

Terence L. Kubar

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Education:

Ph.D. University of Washington (Atmospheric Sciences), October 2008. Advisor Dennis L. Hartmann. Title: "Cloud Structure, Microphysics, and Precipitation in Tropical Clouds Inferred from Satellite Data."

B.S. San Jose State University, 1999-2003. (Major: Meteorology, Minor: Applied Mathematics). Advisor J. Steffens.

Professional Experience:

Jet Propulsion Laboratory, California Institute of Technology, Pasadena (October 2008-Present):
Postdoctorate Research Associate/NASA Fellow: Using multi-sensor satellite and analysis data, am examining the frequency and vertical structure of stratiform low cloud, quantifying the sensitivity of low cloud frequency and structure to various metrics of low-level thermodynamic stability, and further understanding the boundary layer structure as a function of the large-scale circulation.

Department of Atmospheric Sciences, University of Washington, Seattle (2003-October 2008):
Graduate Research Assistant: Using a suite of remote sensing data, studied the vertical and horizontal structure of tropical convection, the relationship between high clouds and clear-sky convergence, tropical cloud radiative forcing, the vertical structure of clouds and precipitation, and the relative importance of microphysics and macrophysics on warm rain frequency and formation in the tropics and subtropics.

Graduate Student Private Tutor (July 2007-November 2007):
Led multiple one-on-one tutoring sessions each week for a probability and statistics course from a health-sciences perspective.

Department of Atmospheric Sciences, University of Washington, Seattle (Fall Quarter 2004 and Winter Quarter 2005):
Teaching Assistant: Atmospheric Science 211: "Climate and Climate Change"; Fall Quarter 2004 instructor: Cecilia Bitz; Winter Quarter 2005 instructor: Qiang Fu.

Weathernews, Sunnyvale, CA (Summers 2000-2002):
Summer Intern: Processed ship report data, prepared post-voyage performance analysis reports, computed statistics about model biases and forecast errors, acquired knowledge about global circulation patterns and shipping routes, prepared daily weather page for *Albany Union* newspaper.

Honors/Awards:
University of Washington Department of Atmospheric Sciences forecasting competition champion (2005).
Graduate School Top Scholar Award recipient (2003).
President's Scholar (five awards per year), San Jose State University (1999-2003).
Golden Key International Honour Society Member (2001-2003).
Dean's Scholar, San Jose State University (2001-2003).

Computational Skills:
Languages: IDL, FORTRAN, C
Operating Systems: Unix/Linux, Windows

Posters, Presentations, Seminars:
•*American Meteorological Society Annual Meeting, Phoenix, AZ (January 2009):*
Presentation: "Understanding the Importance of Microphysics and Macrophysics for Warm Rain in Marine Low Clouds Using MODIS and Cloudsat"

•*American Geophysical Union Joint Assembly and Fall Meeting, San Francisco, CA (December 2008):*
Presentation: "Understanding the Importance of Microphysics and Macrophysics for Warm Rain in Marine Low Clouds Using MODIS and Cloudsat"

•*Jet Propulsion Laboratory, Pasadena, CA (November 2008):*
Aerosol/Cloud Seminar Series: "Understanding the Importance of Microphysics and Macrophysics for Warm Rain in Marine Low Clouds Using MODIS and CloudSat"

•*Department of Atmospheric Sciences, University of Washington, Seattle (September 2008):*
Ph.D. Defense Presentation: "Understanding the Importance of Microphysics and Macrophysics for Warm Rain Using MODIS and CloudSat"

•*American Geophysical Union Joint Assembly and Fall Meeting, San Francisco, CA (December 2007):*
Poster: "The Vertical Structure of Tropical Oceanic Convective Clouds and its Relation to Precipitation"

•*Department of Atmospheric Sciences, University of Washington, Seattle (October 2007):*
Seminar: "The Vertical Structure of Tropical Oceanic Convective Clouds and its Relation to Precipitation"

•*Gordon Conference on Radiation and Climate, Colby-Sawyer College, New London, NH (July-August 2007):*
Poster: "Vertical Structure of Tropical Clouds and Precipitation Across the ITCZ"

•*General Examination, University of Washington, Seattle (May 2007)*:
Presentation: "Vertical and Horizontal Structure of Tropical Convection"

•*American Geophysical Union Joint Assembly and Fall Meeting, San Francisco, CA (December 2006)*:
Presentation: "Radiative Driving of Tropical High Clouds"

•*Second International Conference on Global Warming, Santa Fe, NM (July 2006):*
Poster: "Radiative and Convective Driving of Tropical High Clouds"

•*Atmospheric Sciences Program, University of Alaska Fairbanks (June 2006):*
Seminar: "Radiative and Convective Driving of Tropical High Clouds"

•*Department of Atmospheric Sciences, University of Washington, Seattle (May 2006):*
Seminar: "Radiative and Convective Driving of Tropical High Clouds"

•*Department of Atmospheric Sciences, University of Washington, Seattle (December 2005):*
Seminar: "Tropical Cloud Structures Observed Using Integrated Satellite Data"

•*Gordon Conference on Radiation and Climate, Colby College, Waterville, ME (July 2005):*
Poster: "Tropical Cloud Structures Observed Using Integrated Satellite Data"

•*Department of Atmospheric Sciences, University of Washington, Seattle (September 2004):*
End of First-Year Presentation: "Determination of Tropical Pacific Cloud Structures Using Aqua MODIS Data"

•*Department of Meteorology, San Jose State University, CA (May 2003):*
Senior Thesis Presentation: "The Revision of an RCM and its Coupling With a Carbon-Cycle Model"

Publications (refereed, accepted):

[1] Kubar, T. L., D. L. Hartmann, and R. Wood, 2007: Radiative and convective driving of tropical high clouds. *J. Clim.*, **20**, 5510-5526.
[2] Kubar, T. L. and D. L. Hartmann, 2008: The vertical structure of tropical oceanic convective clouds and its relation to precipitation. *Geophys. Res. Lett.*, **35**, L03804, doi: 10.1029/2007GL032811.
[3] Lopez, M. A., D. L. Hartmann., P. N. Blossey, R. Wood, C. S. Bretherton, and T. L. Kubar, 2009: A test of the simulation of tropical convective cloudiness by a cloud-resolving model. *J. Clim.*, accepted 12/08.
[4] Kubar, T. L., D. L. Hartmann, and R. Wood, 2009: Understanding the importance of microphysics and macrophysics for warm rain in marine low clouds – Part I: satellite observations. *J. Atmos. Sci.*, accepted 4/09.
[5] Wood., R., T. L. Kubar, and D. L. Hartmann, 2009: Understanding the importance of microphysics and macrophysics for warm rain in marine low clouds: Part II: heuristic models of rain formation, *J. Atmos. Sci*., accepted 4/09.

Other Papers:

Kubar, T. L., 2003: The revision of an RCM and its coupling with a carbon cycle model. Senior thesis paper, under supervision of J. L. Steffens.

Research Experience and Interests

Previous Work

a) *Understanding greenhouse gas forcing using radiative convective and simple carbon cycle models*

My one-year senior thesis project as an undergraduate at San Jose State University exposed me to a simple radiative-convective climate model (RCM), and I computed important quantities such as climate sensitivity. I modified the model to allow it to accept time-series inputs of greenhouse gas concentrations, and calculated 20th century greenhouse gas warming, and I also incorporated projected IPCC concentrations of greenhouse gases to simulate 21st century greenhouse gas warming. A simple oceanic carbon cycle model was also used and coupled to the RCM in order to attempt to calculate future CO_2 concentrations based solely on ocean processes.

b) *Towards a thorough understanding of the vertical and horizontal structure of tropical clouds and precipitation using integrated satellite and cloud radar data*

While at the University of Washington, I made extensive use of *Aqua* MODIS satellite data to further our understanding of three different vertical modes convection, particularly in the West and East Pacific Intertropical Convergence Zone (ITCZ). These modes include low boundary layer clouds, mid-level congestus clouds, and deep convective cores and their associated detrained anvil shields and thin cirrus (ref 1).

I also incorporated AMSR-E rain rate data to examine the relationship of different high cloud categories (based on their optical thickness) with convective intensity. The finding of a consistent relationship of high thick cloud with rain rate across the entire Pacific ITCZ demonstrated that thick cloud is a good proxy for rain rate (ref 1). For a given rain rate, the West Pacific contains nearly twice as many high thin clouds compared to the East Pacific, which is radiatively important as more thin high cloud in the West Pacific adds 10 Wm^{-2} to the TOA energy balance compared to the East Pacific (ref 1).

I also quantified a robust relationship between anvil cloud top temperature and the peak in the upper-level convergence associated with the radiative cooling profile in clear sky regions. The maximum in clear-sky upper level convergence is a function partly of the temperature profile, but mostly of the moisture profile, and can explain the observation of colder anvil clouds in the West Pacific versus the East Pacific (ref 1).

I also made extensive use of CloudSat cloud radar data to further investigate the finer vertical structure of clouds, especially multi-layered convection. While high clouds are more likely than middle or lower clouds (all clouds with tops lower than 9.5 km) for a given rain rate (rain rates from AMSR-E) in the West versus the East Pacific, clouds with tops lower than 9.5 km underneath high thin clouds are equally likely in both regions, and occur about 30% of the time, at least for lightly raining or moderately raining clouds (ref 2). Also, deep clouds are taller on average in the West versus the East Pacific (ref 2). I also found that heavily raining cloud systems are considerably deeper than moderately or non-raining clouds by nearly two km (ref 2).

I also extended the CloudSat/AMSR-E analysis to quantify the contribution to total rain amount by different clouds, and found that 38% and 47% in the West and East Pacific of total rain, respectively, fall from clouds with tops lower than 9.5 km. The more bottom-heavy precipitation structure in the East Pacific is consistent with the more bottom-heavy vertical velocity structure there (ref 2).

c) Towards an understanding of the importance of microphysics and macrophysics for warm rain initiation and intensity

I also have thoroughly examined low-level clouds and quantified the relative importance of microphysics and macrophysics in both the intensity and frequency of warm rain using MODIS and CloudSat. Cloud top height and liquid water path substantially increase as drizzle increases. Droplet radius estimated from MODIS also increases with cloud radar reflectivity (dBZ), but levels off as dBZ>0, except where the influence of continental pollution is present, in which case a monotonic increase of effective radius with drizzle intensity occurs. Drizzle *frequency* increases nearly uniformly when cloud tops grow from one to two km. Drizzle frequencies exceed 90% in all regions when liquid water path values exceed 250 g m^{-2} and droplet concentrations are below 50 cm^{-3}, even in regions where drizzle occurs infrequently on the whole (ref 4).

Current Work

Due to the strong negative cloud forcing associate with widespread boundary layer marine low clouds, a small increase (decrease) of them with climate warming has significant implications for offsetting (accelerating) global warming. Thus, an understanding of the meteorological factors important to the sustainability of stratiform warm clouds in our current climate is imperative.

To accomplish this, I am currently using a suite of satellite cloud products (including CloudSat, Calispo and MODIS) as well as ECMWF temperature and humidity data to examine low cloud frequency and vertical structure in a cross-section of the Pacific that spans the deep convective regimes near the equator to the trade cumulus regime to the heart of the stratocumulus regime. An instrument such as Calispo, which is a satellite-borne lidar with high sensitivity to cloud layers, is ideal for examining the fine vertical structure of single-layer boundary layers. Findings thus far reveal that the moist static energy difference between the surface and inversion layer is strongly positively correlated with the frequency of uniform low-level clouds. The inversion height, or height that moist static energy is near zero, also closely corresponds to the low cloud top height when the inversion is relatively strong, such as in the stratocumulus regime off the west coast of North America. From south to north in the Northeast Pacific, the boundary layer drops sharply, from roughly 1500 – 2000 m near 15°N to about 500 m near 35°N, presumably because large-scale subsidence becomes stronger.